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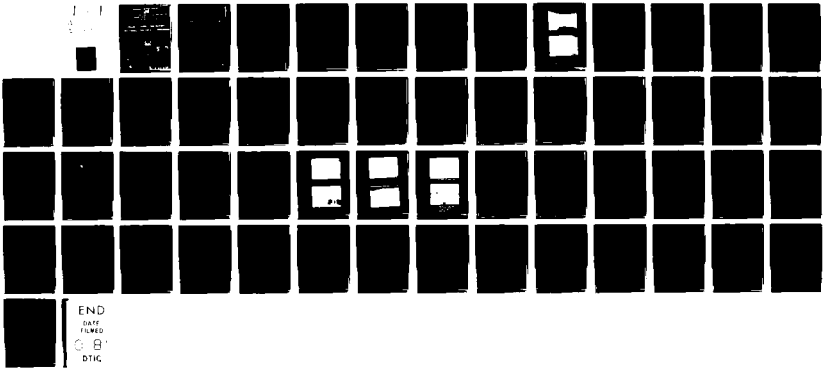

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POTOMAC RIVER BASIN

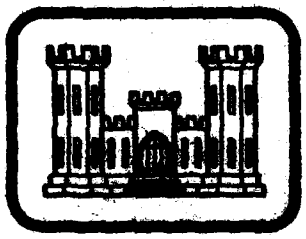
LEVEL II

Name Of Dam: UPPER APPLE MTN. & LOWER APPLE MTN.

Location: WARREN COUNTY

Inventory Number: VA. 18711 & VA. 18709

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM



PREPARED BY
NORFOLK DISTRICT CORPS OF ENGINEERS
803 FRONT STREET
NORFOLK, VIRGINIA 23510

IN CONJUNCTION WITH

COMMONWEALTH OF VIRGINIA
STATE WATER CONTROL BOARD

MARCH 1981

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: VA 18711 & VA 18709
2. GOVT ACCESSION NO.: AD-A103712
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): ~~Phase I Inspection Report~~ National Dam Safety Program, Upper Apple Mountain & Lower Apple Mountain, ~~Warren County, VA~~ Dam (Inventory Number VA 18711 and VA 18709), Potomac River Basin, Warren County, Virginia, Phase I Inspection Report.
5. TYPE OF REPORT & PERIOD COVERED: Final rept.,
6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): ~~Norfolk District, Boris O. Maron~~
8. CONTRACT OR GRANT NUMBER(s): Norfolk District
9. PERFORMING ORGANIZATION NAME AND ADDRESS: U. S. Army ~~Engineer District~~, Norfolk, 803 Front Street, Norfolk, Virginia 23510
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:
11. CONTROLLING OFFICE NAME AND ADDRESS: 12 54
12. REPORT DATE: ~~March~~ 1981
13. NUMBER OF PAGES:
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): 10 Boris O. Maron
15. SECURITY CLASS. (of this report): Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia 22151

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dams - VA
National Dam Safety Program Phase I
Dam Safety
Dam Inspection

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

(See reverse side)

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. Abstract

Pursuant to Public Law 92-367, Phase I Inspection Reports are prepared under guidance contained in the recommended guidelines for safety inspection of dams, published by the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I Inspection is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the gereral conditions of the dam is based upon available data and visual inspection. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to idenify any need for such studies.

Based upon the field conditions at the time of the field inspection and all available engineering data, the Phase I report addresses the hydraulic, hydrologic, geologic, geotechnic, and structural aspects of the dam. The engineering techniques employed give a reasonably accurate assessment of the conditions of the dam. It should be realized that certain engineering aspects cannot be fully analyzed during a Phase I inspection. Assessment and remedial measures in the report include the requirements of additional indepth study when necessary.

Phase I reports include project information of the dam appurtenances, all existing engineering data, operational procedures, hydraulic/hydrologic data of the watershed, dam stability, visual inspection report and an assessment including required remedial measures.

POTOMAC RIVER BASIN

NAME OF DAM: UPPER APPLE MOUNTAIN AND LOWER APPLE MOUNTAIN DAMS
LOCATION: WARREN COUNTY
INVENTORY NUMBER: VA 18711 to VA 18709

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY
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MARCH 1981

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (flood discharges that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the design flood should not be interpreted as necessarily posing a highly inadequate condition. The design flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

BRIEF ASSESSMENT OF DAM

Name of Dam:	Upper Apple Mountain Dam and Lower Apple Mountain Dam
State:	Virginia
Location:	Warren County
USGS Quad Sheet:	Linden
Stream:	Oregon Hollow Run
Date of Inspection:	March 19, 1981

Upper and Lower Apple Mountain Dams are two impounding structures with the tailwater of the Upper Dam being the reservoir water surface of the Lower Dam. The Upper Dam is an earthen embankment about 351 feet long and 34.5 feet high, while the Lower Lake Dam is an earthen embankment about 377 feet long and 32.9 feet high. The dams are owned and maintained by the Apple Mountain Lake Property Owners Association. The dams are classified as small dams with a hazard classification of significant based on location. The emergency spillway for each dam is an earthen channel located at the left abutment of each dam.

Based on criteria established by the Department of the Army, Office of the Chief of Engineers (OCE), the Spillway Design Flood (SDF) is the 100-year flood for each. The emergency spillway of the upper dam will pass 6 percent of the PMF and 100 percent of the SDF without overtopping while the lower dam will pass 4 percent of the PMF and 100 percent of the SDF without overtopping. Therefore, the spillway of each dam is adjudged as adequate.

The visual inspection revealed no apparent problems or remedial measures in need of immediate attention. There is no formal regular maintenance operation program or warning system, and it is recommended that a formal maintenance program and warning system be established. The maintenance items listed in Section 7.2 should be accomplished as a part of the regular maintenance program within the next 12 months.

Submitted By:

Original signed by:
Carl S. Anderson, Jr.

CARL S. ANDERSON, P. E.
Acting Chief, Design Branch

Approved:

Original signed by:
Douglas L. Haller

DOUGLAS L. HALLER
Colonel Corps of Engineers
Commander and District Engineer

Date: JUL 18 1981

Recommended By

Original signed by
JACK G. STARR

JACK G. STARR
Chief, Engineering Division

UPPER DAM & POOL OF LOWER DAM

LOWER DAM

OVERALL VIEW OF APPLE MOUNTAIN LAKE DAMS

19 MARCH 1981

SECTION 1
PROJECT INFORMATION

1.1 GENERAL:

1.1.1 Authority: Public Law 92-367, 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers to initiate a National Program of Safety Inspections of Dams throughout the United States. The Norfolk District has been assigned the responsibility of supervising the inspection of dams in the Commonwealth of Virginia.

1.1.2 Purpose of Inspection: The purpose is to conduct a Phase I inspection according to the Recommended Guidelines for Safety Inspection of Dams (Reference 1, Appendix IV). The main responsibility is to expeditiously identify those dams which may be a potential hazard to human life or property.

1.2 Project Description:

1.2.1 Dam and Appurtenances: Upper and Lower Apple Mountain Dam are two impounding structures with the tailwater of the Upper Dam being the reservoir water surface of the Lower Dam. The Upper Dam is an earthen embankment about 351 feet long 1/, 34.5 feet high 2/, crest width of 13 feet and a minimum crest elevation of 823.2 MSL 3/ adjacent to the emergency spillway. The right abutment elevation of the Upper Dam is 823.8 MSL. The crest rises uniformly from the right abutment to a maximum elevation of 824.3 MSL at Station 3+00 (measured from the left abutment). The upstream embankment face has a slope of 2.2 horizontal to 1.0 vertical (2.2H:1V); the downstream face slopes 2.5H:2V.

The Lower Dam is an earthen embankment about 377 feet long, 32.9 feet high, crest width of 14.5 feet and a minimum crest elevation of 792.9 MSL adjacent to the emergency spillway. The Lower Dam crest does not have a uniform elevation; from Station 0+17 (as measured from the left abutment) with an elevation of 792.9 MSL, the crest rises to elevation 793.8 MSL at Station 1+00, drops to elevation 793.3 MSL at Station 3+00, then rises again to elevation 793.6 MSL at Station 4+00. The upstream face of the embankment has a slope of 2.2 horizontal to 1.0 vertical (2.2H:1V); the downstream face slopes 2.5H:1V.

1/ Dam length is measured from natural ground at the left abutment to natural ground at the right abutment. The width of the emergency spillway is not considered part of the dam length.

2/ Dam height based on the difference is elevation between the streambed at the toe of the dam and the maximum height of the crest.

3/ TBM (Temporary Bench Mark) - Top of a two foot concrete masonry wall located on the right abutment area. This elevation was assumed to be 100.0 feet for the survey and was later correlated to the U.S.G.S. quad sheet to simplify hydrology calculations.

It is unknown whether either the Upper or Lower Dam has foundation drainage. There were no foundation drain outlets visible. It has been reported that both dams were constructed with the benefit of a cutoff trench. There is no slope protection on either dam.

The principal spillway intake for the Upper Dam consists of 18-inch corrugated metal pipe (CMP), invert elevation 820.0 MSL, protected by a 24-inch corrugated metal pipe (CMP) trash guard located at the water's edge on the upstream face at Station 2+00. The principal spillway outlet of the Upper Dam is a 12-inch CMP, invert elevation 789.8 MSL, that discharges at the dam toe into a marsh area in the upper reaches of the lower reservoir.

The principal spillway intake for the Lower Dam consists also of an 18-inch CMP riser, invert elevation 789.7 MSL, protected by a 24-inch guard about 10 feet out into the reservoir at Station 1+25 on the upstream face. The principal spillway outlet of the Lower Dam is a 12-inch corrugated metal pipe, invert elevation 761.7 MSL, that discharges into a small stilling basin at the toe of the Lower Dam.

The emergency spillway for the Upper Dam consists of an earthen side channel located at the left abutment with an average width of 6 feet and an average control section elevation of 822.1 MSL.

The emergency spillway for the Lower Dam consists of an earthen side channel located at the left abutment with an average width of 5 feet and an average control section elevation of 792.3 MSL.

1.2.2 Location: Apple Mountain Dams are located 4 miles east of Front Royal, Virginia and one mile northwest of the exit for Linden, Virginia on I-66.

1.2.3 Size Classification: Both the Upper and Lower Dams are classified as small size structures on the basis of their height.

1.2.4 Hazard Classification: A few occupied structures are located in the valley below the dams. Therefore, a significant hazard classification is given for these structures according to guidelines contained in Section 2.1.2 of Reference 1, Appendix IV. The hazard classification used to categorize dams is a function of location only and has nothing to do with their stability or probability of failure.

1.2.5 Ownership: The dams are owned by the Apple Mountain Lakes Property Owners Association, Incorporated.

1.2.6 Purpose: The dams (reservoirs) are used for recreation of the property owners in Apple Mountain Lake Subdivision.

1.2.7 Design and Construction History: The design of the dams is unknown but were built by Price Radin Corporation (First American Group) with completion in 1973. The name of the actual contractor can not be verified, but it has been reported that the dams were constructed by Moore, Kelly, and Reddish.

1.2.8 Normal Operational Procedures: Water from both the Upper and Lower reservoirs passes through the principal spillways as the reservoir rises above the intakes. In case the reservoirs rise above the crest of either emergency spillway, the water would then automatically pass through the emergency spillways as required.

1.3 Pertinent Data:

1.3.1 Drainage Area: The Upper Dam controls 0.08 square miles and the Lower Dam controls flow from the upper dam and 0.02 square miles of local area around the lower reservoir.

1.3.2 Discharge at Dam Site: Maximum flood unknown.

1.3.3 Dam and Reservoir Data: Pertinent data on the dam and reservoir are shown in the following table:

TABLE 1.1 DAM AND RESERVOIR DATA

UPPER DAM (ID No. VA. 18711)

Item	Elevation Feet MSL	Reservoir Capacity Area (ac)	Reservoir Capacity Acre (ft)	Watershed (in)	Length (mi)
Top of Dam					
Highest Point	824.3	1.61	24.8	5.8	.1
Lowest Point	823.2	1.44	22.5	5.3	.1
Emergency Spillway Crest	822.1	1.35	21.0	4.9	.1
Principal Spillway Crest	820.0	1.15	17.3	4.1	.1
Stream at Downstream Toe of Dam	789.7	----	----	----	—

TABLE 1.1 DAM AND RESERVOIR DATA

continued

LOWER DAM (ID No. VA 18709)

Item	Elevation Feet MSL	Reservoir Area (ac)	Reservoir Capacity Acre (ft)	Reservoir Capacity Watershed (in)	Length (mi)
Top of Dam					
Highest Point	793.8	2.8	42.0	7.9	.1
Lowest Point	792.9	2.7	40.1	7.5	.1
Emergency Spillway Crest	792.3	2.6	38.0	7.1	.1
Principal Spillway Crest	789.7	2.3	32.0	6.0	.1
Stream at Downstream Toe of Dam	760.9	----	----	----	—

SECTION 2

ENGINEERING DATA

2.1 DESIGN: There is no known design information.

2.2 CONSTRUCTION: There are no known construction records.

2.3 EVALUATION: There is insufficient information to evaluate foundation conditions and embankment stability.

SECTION 3

VISUAL INSPECTION

3.1 Findings:

3.1.1 General: The results of the 19 March 1981 are recorded in Appendix III. The weather was overcast, temperature 35°F, ground condition moist due to light snow the previous day and snow showers earlier that morning. This inspection consisted of two embankments, an Upper Dam and Lower Dam. The upper reservoir pool elevation was at 819.8 MSL with a principal spillway consisting of a riser and conduit through the embankment. An 18-inch corrugated metal pipe makes up the vertical drop inlet riser connected to a 12-inch corrugated metal pipe passing through the embankment at a low level and discharging into a small marsh area serving as the headwaters of the lower reservoir. The emergency spillway is an earthen channel located at the left abutment.

The lower reservoir pool elevation was at 787.6 MSL, two feet below the principal spillway crest. The principal spillway consists of a riser and conduit through the embankment. An 18-inch corrugated metal pipe makes up the vertical drop inlet riser connected to a 12-inch corrugated metal pipe passing through the embankment at a low level discharging into a small plunge pool. The emergency spillway of the lower reservoir is an earthen channel located at the left abutment. There are no known prior inspections of either dam.

3.1.2 Embankment: The embankments of both the upper and lower reservoirs were in good condition. Sketches showing the plan views, crest profiles and cross sections are provided as Plates II and III in Appendix I. Pictures of the dams are provided in Appendix II.

The upper embankment did not have any signs of surface cracks, sloughing, or misalignment although there was minor erosion and bare areas.

There was no visible riprap on the upstream face. The crest of the upper embankment is crowned toward the center such that it is higher than each abutment. A wet spot was identified as a suspected spring near the foot path at the right abument, another suspected seep was found at the toe in a marshy area extending from the base of the left abutment, one-third across the downstream face toward the right abutment. The upstream and downstream slopes have a fair covering of grass with some underbrush, with saplings of locust and sumac as well as honeysuckle and briers. An extensive growth of cattails is at the downstream toe. The foundation appeared stable while it was presumed that materials used to construct the dam were from local borrow areas which appear to be residual silts and silty clays.

The lower embankment did not have any signs of surface cracks, sloughing or misalignment although there was erosion at the right abutment contact on the downstream face caused by hillside runoff. One animal burrow was observed next to the outlet. There was no visible riprap on the upstream face. The crest of the lower embankment did not have a uniform elevation.

It was somewhat irregularly crowned towards the left abutment. Widespread standing water was found at the toe of the downstream face while flowing water was observed on the lower portion of the left abutment contact. The estimated flow has determined to be three gallons per minute (gpm) by field measurement. The upstream and downstream slopes have a fair covering of grass with a few bushes on the upstream slope while the downstream slope has many locust saplings. Cattails are present along the water's edge at various locations.

The toe area was overgrown with brush and small trees. The foundation appeared stable. It was presumed that materials used to construct the dam were from local borrow areas the same as the upper dam.

3.1.3 Principal Spillways: Upper Dam - An 18-inch corrugated metal pipe, located at the water's edge, serves as the principal spillway drop inlet riser with a section of 24-inch corrugated metal pipe as a trash guard.

The 18-inch vertical riser is connected to a 12-inch corrugated metal pipe passing through the embankment at a low level and discharging into a marsh area in the upper reaches of the lower reservoir at the toe of the upper dam. There is an animal burrow next to the outlet. A pole standing vertically in the reservoir, beyond the 18-inch corrugated metal pipe intake, may indicate the presence of an emergency drain.

Lower Dam - An 18-inch corrugated metal pipe serves as the drop-inlet riser of the principal spillway, with a section of 24-inch corrugated metal pipe as a trash guard. The 18-inch CMP riser is connected to a 12-inch corrugated metal pipe passing through the embankment at a low level and discharging into a small plunge pool surrounded by saplings. At the time of inspection, the flow appeared to be from leakage rather than from normal flow. A pole standing vertically in the reservoir, beyond the 18-inch corrugated metal pipe intake, may indicate the presence of an emergency drain.

3.1.4 Emergency Spillways: Upper Dam - The emergency spillway is an earthen channel located at the left abutment. The approach channel was partially obstructed by brush and small trees. The discharge channel is down the left abutment contact and is partially blocked by brush and small trees.

Lower Dam - The emergency spillway is an earthen channel located at the left abutment. The approach channel was partially obstructed by a few bushes and deposited debris. The discharge channel is down the left abutment contact which is partially blocked by brush and trees.

3.1.5 Instrumentation: There is no instrumentation on either the Upper or Lower Dams.

3.1.6 Reservoir Areas: Upper and Lower Reservoirs - The slopes of both watersheds are steep and wooded with a mixture of pines and hardwoods. Neither reservoir slope showed any signs of failure while both showed some signs of shoreline erosion. Sedimentation was not evaluated in either reservoir.

3.1.7 Downstream Channel: The channel immediately below the Upper Dam is overgrown with cattails and is the headwater of the Lower Reservoir whereas the channel downstream from the Lower Reservoir is a natural streambed through terrain characterized as hilly to mountainous. There are two frame dwellings and a mobile home some distance downstream from the dam.

3.2 EVALUATION: Upper Dam - Overall, the dam appears to be in good condition. However, the inspection revealed certain preventive maintenance items which should be scheduled as part of an annual maintenance program.

These are as follows:

(a) Check the embankment for animal burrows during periodic maintenance inspections and if found, fill with well compacted soil. These areas should also be sodded or seeded with grass.

(b) Cut trees and brush on the dam to the ground and keep the embankment mowed to maintain a grass cover and prevent the encroachment of underbrush. All trees with diameters greater than three inches should have the root ball and root structure removed. All subsequent holes should be filled with well compacted soil and these areas should be sodded or seeded.

(c) Clear the underbrush and cattails from the principal spillway outlet area.

(d) Monitor the flows in the seep areas and should any of the flows increase or become turbid, retain the service of a qualified geotechnical engineering firm to evaluate the stability of the concerned dam.

(e) Cut and control vegetation at the toe of the dam in order to facilitate routine observation of toe area.

(f) Clear both the approach and discharge channels of the emergency spillway to insure an unobstructed flow.

(g) Install a staff gage permanently mounted to show the depth of flow through the emergency spillway and overtop of the dam.

Lower Dam - Overall the dam appears to be in good condition. However, the inspection revealed certain preventive maintenance items which should be scheduled as part of an annual maintenance program. These are as follows:

(a) Check the embankment for animal burrows during periodic maintenance inspections and if found fill with well compacted soil. These areas should also be sodded or seeded with grass.

(b) Cut trees and brush on the dam to the ground and keep the embankment mowed to maintain a grass cover and prevent the encroachment of underbrush. All trees with diameters greater than three inches should have the root ball and root structure removed. All subsequent holes should be filled with compacted soil and these areas should be sodded or seeded.

(c) Clear the saplings/trees/underbrush from the outlet area, enlarge the stilling basin (plunge pool), install riprap to prevent erosion and clear the downstream channel to such an extent as not to impede the flow.

(d) Monitor the flows in the seep areas and should any of the flows increase or become turbid, retain the service of a qualified geotechnical engineering firm to evaluate the stability of the concerned dam.

(e) Remove and control vegetation at the toe of the dam in order to facilitate observation during periodic maintenance inspections.

(f) Clear both the approach and discharge channel of the emergency spillway to insure an unobstructed flow.

(g) Install a staff gage permanently to show the depth of flow through the emergency spillway and over top of the dam.

SECTION 4

OPERATIONAL PROCEDURES

4.1 Procedures: The normal reservoir pool elevation for the Upper Reservoir is 820.0 MSL. This is the elevation of the crest of the 18-inch corrugated metal riser pipe intake which is the principal spillway. The Lower Reservoir has a normal pool elevation of 789.7 MSL. This is also the elevation of the crest of the 18-inch corrugated metal riser pipe intake which is its principal spillway. Water passes automatically over the crest of each intake respectively as the water level in each reservoir rises above the crest. Ultimately, water will pass through the emergency spillway of each reservoir when the water level rises above the elevation of the respective crests.

4.2 Maintenance: General maintenance work is accomplished by the property owners association at the dam as required.

4.3 Warning System: At the time of inspection there was no established warning system or evacuation plan for the Apple Mountain Lake Dams.

4.4 Evaluation: The dams do not require an elaborate operation and maintenance program. However, a program should be developed to help detect and correct any problems that might arise.

An emergency operation and warning plan should be developed to include whom to notify, including local public officials in case evacuation from the downstream area becomes necessary. The local EMERGENCY SERVICES COORDINATOR of the STATE OFFICE OF EMERGENCY AND ENERGY SERVICES should be included in the list of the public officials to be notified.

SECTION 5

HYDRAULIC/HYDROLOGIC DATA

5.1 Design: None were available.

5.2 Hydrologic Records: None were available.

5.3 Flood Experience: Unknown.

5.4 Flood Potential: The 100 Year Flood, 1/2 PMF, and PMF were developed by use of the HEC-1 computer program (Reference 2, Appendix IV) and routed through the reservoirs by use of the NWS-DAMBREAK computer program (Reference 3, Appendix IV) and appropriate unit hydrograph, precipitation and storage outflow data. Clark's Tc and R coefficients for the local drainage areas were estimated from basin characteristics. The rainfall applied to the developed unit hydrograph was obtained from National Weather Service Publications (Reference 4 and 5, Appendix IV).

5.5 Reservoir Regulation: Pertinent dam and reservoir data are shown in Table 1.1.

Water passes automatically through the principal and emergency spillways as the water level in the reservoirs rises above the spillway crests.

The storage curves were developed based on areas obtained from a U. S. Geological Survey Quadrangle Map. Survey data taken during the inspection was correlated to the Linden, Virginia Quadrangle Map to help develop the area-storage data. Rating curves for the principal and emergency spillways and non-overflow sections were developed. In routing hydrographs through the reservoirs, it was assumed that the initial pool level was at the principal spillway crest. (Elevation 820.0 upper dam and 789.7 lower dam.)

5.6 Overtopping Potential: The probable rise of the reservoirs and other pertinent information on reservoirs performance is shown in the following table:

Table 5.1 RESERVOIR PERFORMANCE

UPPER DAM (ID VA NO 18711)

Item	Normal Flow	100 Year Flood 1/	1/2 PMF	PMF 2/
Peak Flow c.f.s.				
Inflow	.1	92.0	363.0	726.0
Outflow	.1	22.0	354.0	721.0
Maximum Elevation ft. msl.	820.0	822.2	824.0	824.4
Non-overflow section (Minimum Elevation 823.2)				
Depth of flow, ft.	---	---	0.8	1.2
Duration, hrs.	---	---	1.0	1.7
Velocity, fps 3/	---	---	4.1	5.1
Tailwater Elevation ft. msl 4/	789.7	---	---	---

Lower Dam (ID VA NO. 18709)

Item	Normal Flow	100 Year Flood 1/	1/2 PMF	PMF 2/
Peak Flow c.f.s.				
Inflow	.1	75.0	377.0	1100.0
Outflow	.1	18.0	364.0	1083.0
Maximum Elevation ft. msl.	789.7	791.2	794.0	794.5
Non-overflow section (Minimum Elevation)				
Depth of flow, ft. 793.0	---	---	0.7	1.2
Duration, hrs.	---	---	2.1	2.5
Velocity, fps.	---	---	3.9	5.1
Tailwater Elevation ft. msl.	760.9	---	---	---

1/ The 100-Year Flood has one chance in 100 of occurring in any given year.
2/ The PMF is an estimate of flood discharges that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.
3/ Critical Velocity
4/ The tailwater of the upper dam is the water surface of the lower dam.

5.7 Reservoir Emptying Potential: It was not known if a low level outlet for dewatering the reservoirs existed, therefore the reservoir emptying potential was not considered.

5.8 Evaluation: Based on their size (small) and hazard classification (significant) the recommended Spillway Design Flood is the 100 Year Flood to the 1/2 PMF. Because of the risk involved, the 100 Year Flood has been selected as the SDF. The spillway of the upper dam will pass 6 percent of the PMF or 100 percent of the SDF. The spillway of the lower dam will pass 4 percent of the PMF or 100 percent of the SDF.

Conclusions pertain to present day conditions. The effects of future development on the hydrology has not been considered.

SECTION 6

DAM STABILITY

6.1 Foundation and Abutments: There is no information available on the foundation conditions, except what can be inferred from geologic studies of the area field observations. The Apple Mountain dams are located near the Western edge of the Blue Ridge physiographic province. The site is situated at the contact of two geologic formations: the Catoctin on the east and the narrow northeast trending Weverton to the west. The area lies on the northwest limb of the Blue Ridge anticlinorium, a major geologic structure of the region.

The site is about one and a half miles north of the east-west trending Front Royal fault, and is bracketed by smaller faults to the northwest and northeast.

The basic reference for the geology of the vicinity is Geology of the Linden and Flint Hill Quadrangles, Virginia, published by the Virginia Division of Mineral Resources.

Most of the site is underlain by the Catoctin formation, with bedrock here consisting chiefly on metabasalt and volcanic purple slate. The area of the left shoreline and abutments of both lakes are underlain by the Weverton formation, characterized by quartzite and quartz pebble conglomerate, sandy phyllites, and sandstone bedrock. Weathered exposures of both formations may be observed at the site.

Although there are no known existing records documenting the construction of the dam, good engineering practice would have been to excavate down to the shale bedrock, either over the entire base area of the dam or at least for a cutoff trench section. This would be facilitated by the fact that the bedrock should be at a relatively shallow depth, judging from the presence of nearby outcrops. This was in fact done, according to Mr. Goodwin Moore of Moore, Kelly, and Reddish, who in the course of a subsequent inspection of another dam which he had built, indicated that he had constructed the Apple Mountain dams also. He also said that the embankments were constructed with the clayier material in the cutoff trench and the central portions of the dams. Toe drains were not included in the design.

The soils in the area appear, on the basis of limited field observation, to be residual silts and silty clays of medium to high plasticity formed by weathering of the underlying rock. They should be relatively impervious and stable, particularly if care was taken during construction to guard against the potential problems associated with plastic clays. Bedding and foliation planes in the bedrock in the vicinity strike in a direction generally perpendicular to the axes of the dams, providing potential avenues of seepage.

However, the compact character of much of the bedrock typical of the area is such that in an unweathered, unfractured condition, would not be a problem.

There are several wet spots on the site that have the appearance of natural springs, but there was no present evidence of excessive seepage beneath or through the dams. However, it appears that on the Upper Apple Mountain dam a line of seepage may be breaking out over about one-third of the downstream face (toward the left abutment) at roughly the elevation of the foot path which traverses the downstream face in that area. In conclusion, foundation conditions for both of the dams would be generally good.

6.2 Embankment:

6.2.1 Material: There is little information available on the nature of the embankment materials, although Mr. Moore indicated that a sufficient quantity of clayey material was available to form cores for the embankments. It is likely that the source of borrow for the dams was located in the vicinity of the lakes, with a considerable portion probably coming from within the area presently covered by the impoundments. As noted, the area soils appear to be residual silts and silty clays of medium to high plasticity.

6.2.2 Stability: There are no available stability calculations. The Upper dam is 33.4 feet high and 13 feet wide at the crest. Its upstream slope is 2.2H:1V and the downstream slope is 2.5H:1V. The dam was designed for a normal pool elevation of 820.0 MSL feet. The maximum storage pool is 822.1, the elevation of the emergency spillway's lowest point. The dam is not presently subjected to a sudden drawdown. A low level drain, if in fact present, is assumed to be inoperable at this time. The existing pool is approximately 2.3 feet below maximum control storage pool which is at the crest of the emergency spillway; in other words, there is presently 2.3 feet of freeboard. It is not known for a certainty whether or not the dam has ever been subjected to a maximum control storage pool (water at the elevation of the emergency spillway), but it is doubtful that it has.

The dimensions of the Lower dam are generally similar. It is 32.9 feet high and 14.5 feet wide at the crest. Its upstream slope is 2.2H:1V and the downstream slope is 2.5H:1V. The dam was designed for a normal pool elevation of 789.7 MSL feet. The maximum storage pool is 792.3 MSL, which is the elevation of the emergency spillway's lowest point. The dam is not presently subject to a sudden drawdown. A low level drain, if in fact present, is assumed to be inoperable at this time. The existing pool is approximately 4.7 feet below maximum control storage pool which is at the crest of the emergency spillway; in other words, there is presently 4.7 feet of freeboard. It is not known for a certainty whether or not the dam has ever been subjected to a maximum control storage pool (water at the elevation of the emergency spillway), but it is doubtful that it has.

According to the guidelines presented in Design of Small Dams, U.S. Department of the Interior, Bureau of Reclamation, the slopes recommended for a homogeneous small dam of similar material not subjected to a rapid drawdown are 3H:1V upstream and 2.5H:1V downstream. The recommended width is 16.5 feet.

Based on these guidelines, the Upper dam has an inadequate upstream slope, and an adequate downstream slope. Its crest width of 13.0 feet is somewhat less than recommended. Although both dams are reported to have been constructed with a central core, because neither the exact nature of the material used to construct the core and outer portions nor the dimensions of the central portion are known, the dams are considered to be homogeneous for the purpose of stability assessment.

The same slope and width criteria apply to the lower dam, so based on the same guidelines, the Lower dam also has an inadequate upstream slope and an adequate downstream slope. The lower dam's crest width is two feet less than the recommended 16.5 feet.

6.2.3 Seismic Stability: The site is located in Seismic Zone ?. Therefore, according to the Recommended Guidelines for Safety Inspection of Dams, the dams are considered to have no hazard from earthquakes provided that static stability conditions are satisfactory and conventional safety margins exists.

6.3 Evaluation: There is insufficient information to adequately evaluate the stability of the dams. However, the visual inspection revealed no apparent instability. The apparent seepage line on the downstream face of the Upper dam should be observed regularly. Should it extend all the way across the dam or higher up on its downstream face, or if sloughing or sliding or other indications of instability become apparent on the downstream face, a geotechnical engineering firm should be consulted for recommendations to avoid a possible slope failure. Based on the Bureau of Reclamation guidelines, the upstream slopes of both dams are inadequate, the downstream slopes are adequate, and the crest widths are somewhat less than recommended. The embankments are considered stable during both normal pool and maximum storage pool operations. In addition, overtopping is not a problem because the spillways will pass the spillway design flood (100-year flood) selected for these structures without overtopping them. Stability calculations are not required.

SECTION 7

ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment: The visual inspection did not reveal any findings that would prove the dams unsound. Overall, the dams are in good conditions and there is no immediate need for remedial measures.

There is no regular maintenance program nor is there an emergency warning plan.

The Corps of Engineers guidelines indicate the appropriate Spillway Design Flood (SDF) for these dams is the 100-year flood since each dam is classified as being small size with a significant hazard classification.

The spillway for the Upper dam will pass 6 percent of the PMF and 100 percent of the SDF without overtopping the dam. Therefore, the spillway is adjudged as adequate. The spillway for the Lower Dam will pass 4 percent of the PMF and 100 percent of the SDF without overtopping the dam. Therefore, the Lower Dam spillway is adjudged as adequate.

A stability check at this time is not required for either dam.

7.2 RECOMMENDED REMEDIAL MEASURES: It is recommended that a regular maintenance program be formalized for future reference. A formal emergency procedure and warning system should be developed and put into operation as soon as possible. This should include how to operate the dam during an emergency, and who to notify, including public officials, in case evacuation from the downstream area is necessary. The local Emergency Services Coordinator of the State Office of Emergency and Energy Services can assist in the preparation of an Emergency Warning Plan.

Also, the inspection revealed the following maintenance items that should be scheduled during a regular maintenance period within the next 12 months:

(a) Check the embankments for animal burrows during periodic maintenance inspections and if found, fill with well compacted soil. These areas should also be sodded or seeded with grass.

(b) Cut trees and brush on the dams to the ground and keep the embankments mowed to maintain a grass cover and prevent the encroachment of underbrush. All trees with diameters greater than three inches should have the root ball and root structure removed. All subsequent holes should be filled with well compacted soil and these areas should be sodded or seeded.

(c) Cut control vegetation at the toes of the dams in order to facilitate observation during periodic maintenance inspections.

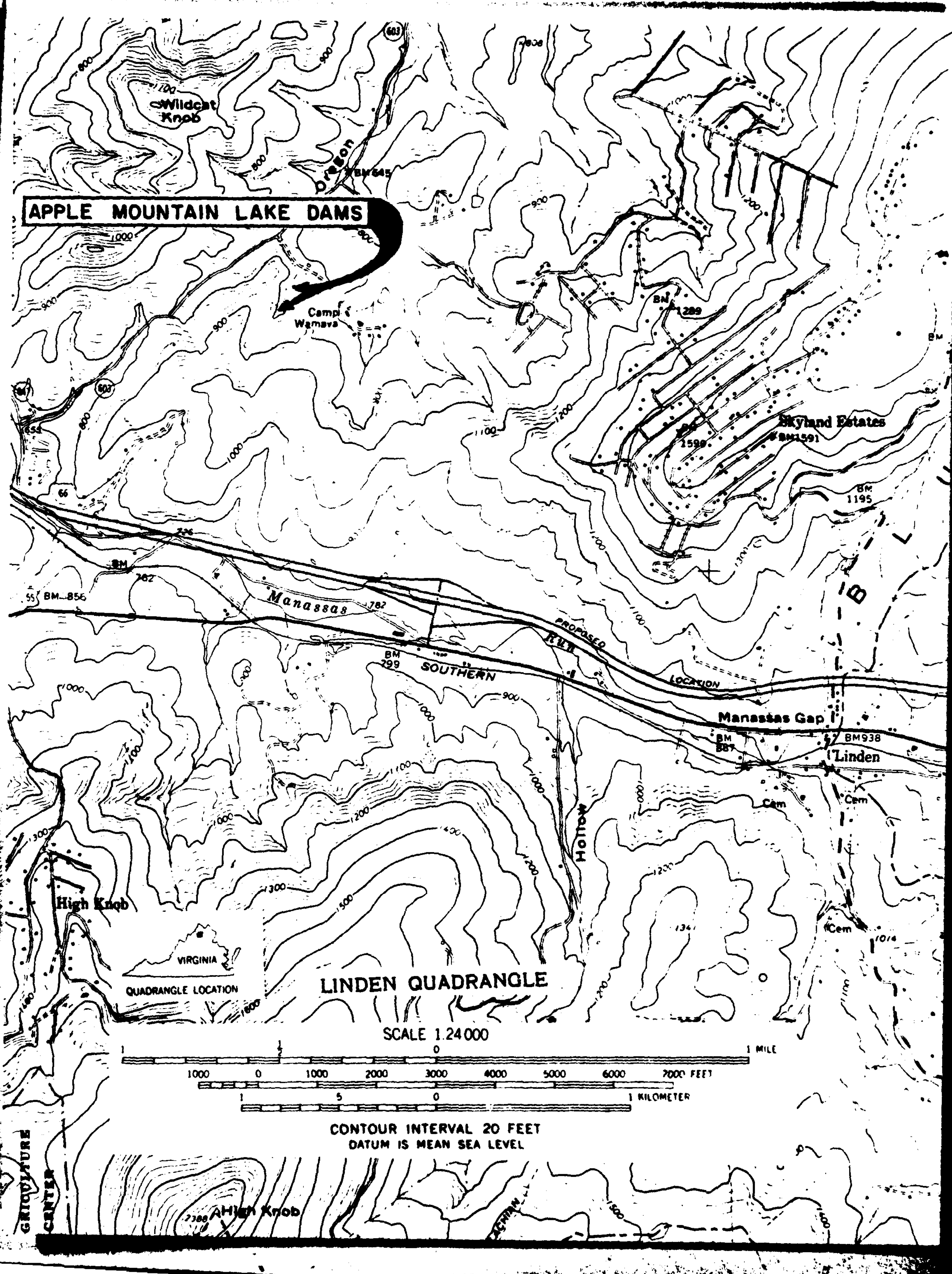
(d) Clear both the approach and discharge channels of the emergency spillways of each dam to insure an unobstructed flow.

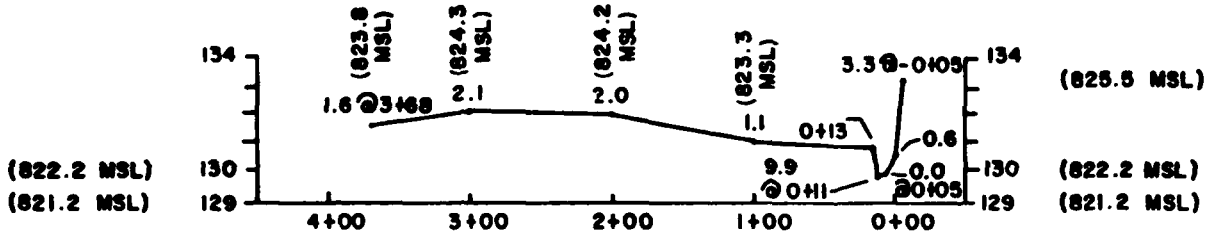
(e) Install staff gages permanently in such a manner to determine the depth of water flowing through each emergency spillway and depth overtop of each dam should it occur.

(f) Monitor the flows in the seep areas and should any of the flows increase or become turbid retain, the service of a qualified geotechnical engineering firm to evaluate the stability of the concerned dam.

APPENDIX I

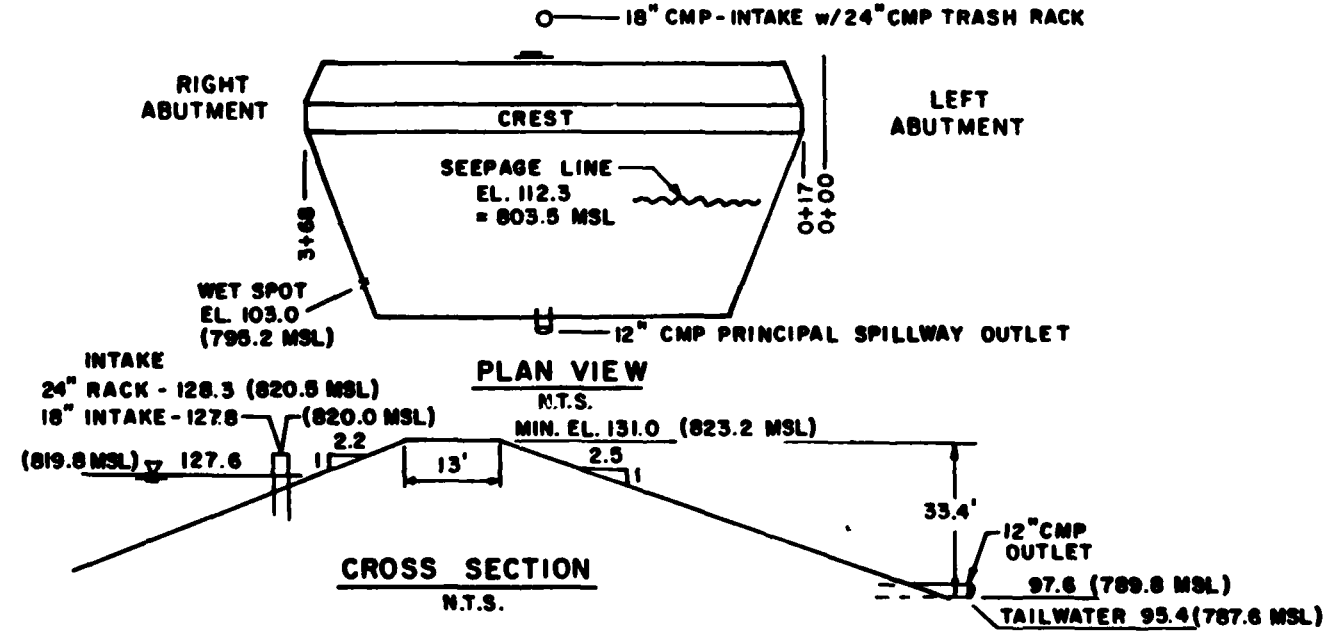
MAPS AND DRAWINGS


APPLE MOUNTAIN LAKE DAMS
Wildcat Knob
Dragon
BM 845
Camp Wamava
Skyland Estates
BM 1591
BM 1289
BM 1195
Manassas Run
PROPOSED LOCATION
SOUTHERN
BM 856
BM 782
BM 799
Manassas Gap
BM 887
BM938
Linden
Cem
Hollow
High Knob
VIRGINIA
QUADRANGLE LOCATION
LINDEN QUADRANGLE
SCALE 1:24 000
1 MILE
7000 FEET
1 KILOMETER
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
High Knob
AGRICULTURE CENTER



CREST PROFILE

SCALE AS SHOWN



PLAN VIEW

N.T.S.

CROSS SECTION

N.T.S.

NOTES: 1. TAILWATER IS THE RESERVOIR OF THE LOWER DAM. THE POOL WAS BELOW NORMAL AND WAS APPROXIMATELY 35 FT. D.S. OF THE TOE OF THE UPPER DAM. THE EXPOSED LAKE BOTTOM WAS ON A 16H:1V SLOPE.

2. ELEVATIONS BASED ON TBM LOCATED AT LOWER DAM.

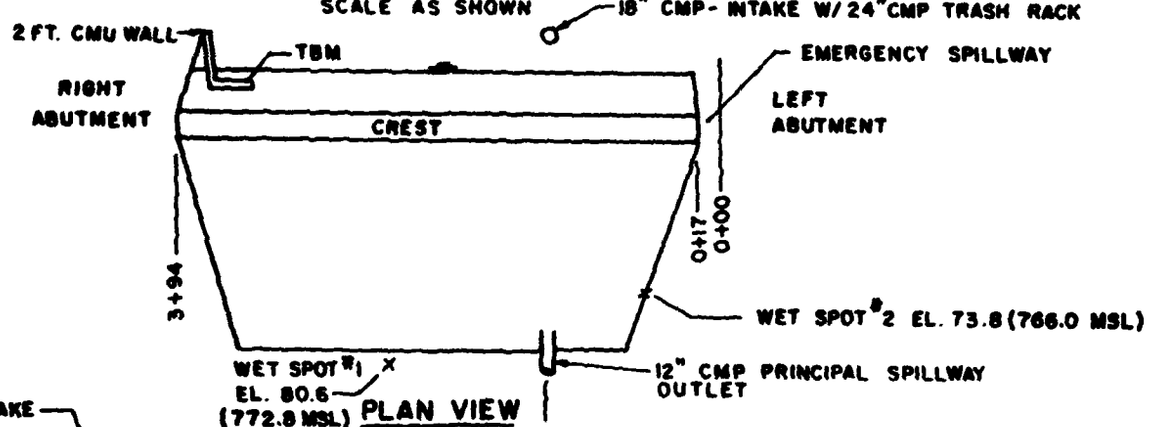
UPPER APPLE MOUNTAIN

19 MAR. 1981

PLATE II

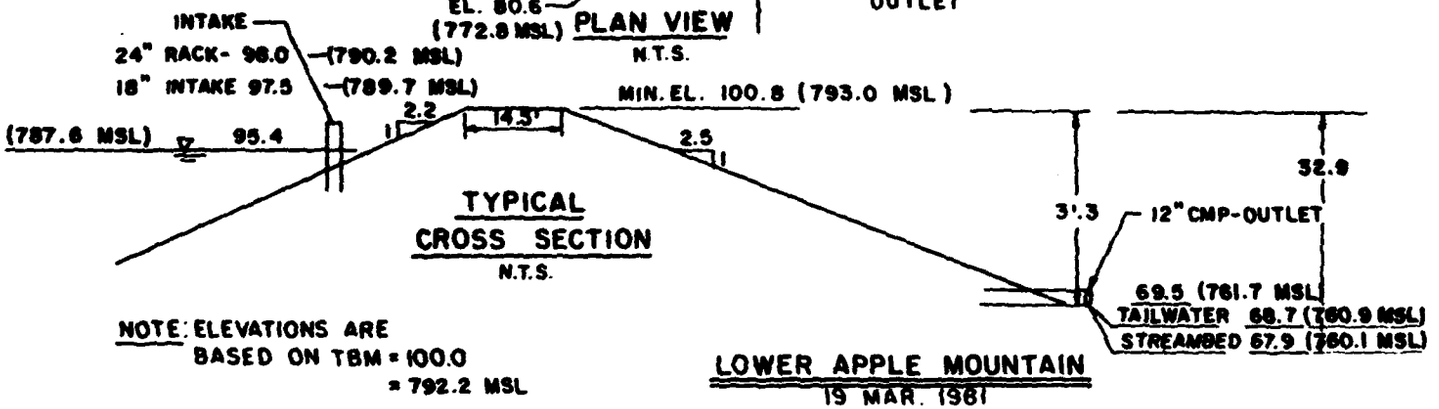
CREST PROFILE

SCALE AS SHOWN



PLAN VIEW

N.T.S.



TYPICAL CROSS SECTION

N.T.S.

NOTE: ELEVATIONS ARE BASED ON TBM = 100.0 = 792.2 MSL

LOWER APPLE MOUNTAIN

19 MAR. 1981

PLATE III

APPENDIX II

PHOTOGRAPHS

PHOTO #1 CREST OF LOWER DAM

PHOTO #2 CREST & UPSTREAM FACE
OF LOWER DAM

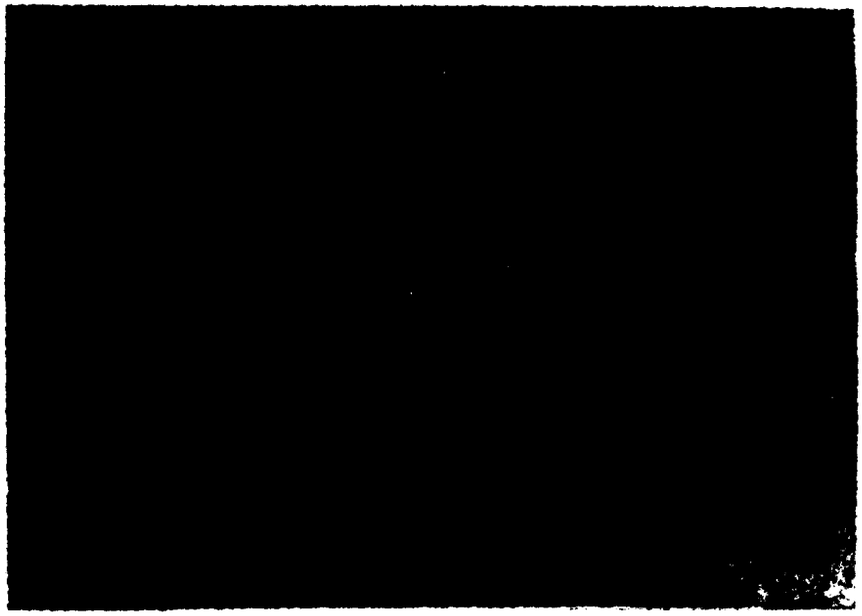


PHOTO #3 DOWNSTREAM FACE
OF LOWER DAM

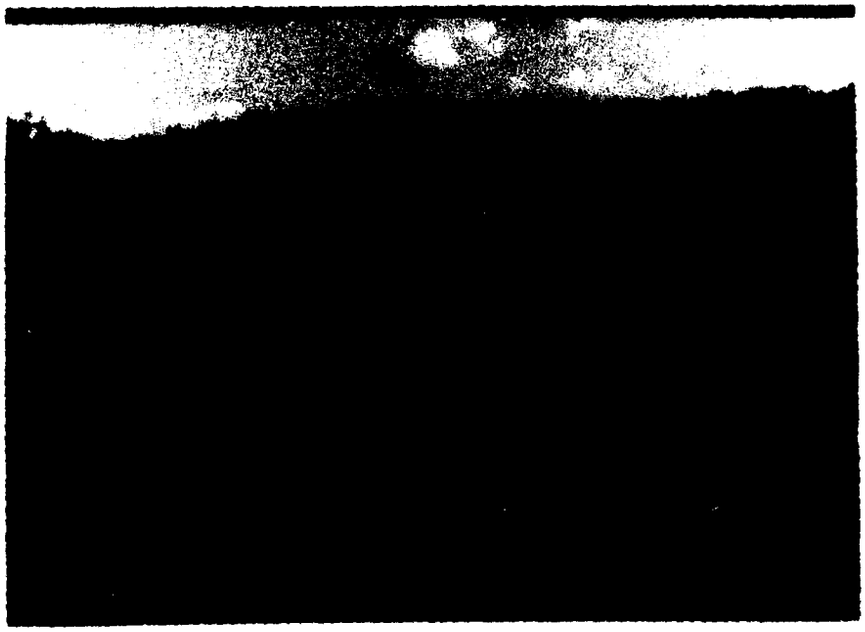


PHOTO #4 VIEW FROM CREST OF UPPER
DAM LOOKING DOWNSTREAM

PHOTO #5 CREST OF UPPER DAM

PHOTO #6 INTERCEPTED FLOW FROM SEEP/ SPRING NEAR CONTACT OF LT. ABUTMENT-EMBANKMENT OF LOWER DAM

APPENDIX III

FIELD OBSERVATIONS

Check List
Visual Inspection
Phase I

Name Dam: Upper Apple Mountain County: Warren State: Virginia Coordinates: Lat. 38° 55.9'
Long. 78° 16.4'

Date Inspection: 19 Mar 81 Weather: Partly cloudy & cold Temperature: 35° - 35° F

Pool Elevation at Time of Inspection: 127.6 TBM* Tailwater at Time of Inspection: 95.4 TBM

Inspection Personnel:

B. Taran, COE
J. Robinson, COE
D. Pezza, COE
L. Jones, COE
E. Constantine, SWCB
H. Gildea, SWCB
D. Bushman, SWCB
L. Musselwhite, SWCB

Apple Mountain
Property Owners Association:

Mr. Ed. Jewel

H. Gildea Recorders

*TBM - Temporary Bench Mark: Concrete wall at right abutment of Lower Apple Mountain Lake, assumed to be at elevation 100.0 feet.

EMBANKMENT
UPPER APPLE MOUNTAIN

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	No surface cracks were observed.	None.
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	No unusual movement or cracking was observed. The toe area is a marsh with tall grass and cattails, partially submerged by the reservoir of the lower impoundment.	Control vegetation to facilitate the observation of piping or other problems in the toe area. Submergence of toe of a dam by lake of a lower dam is not a recommended practice.
SLOUCHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	There is very minor erosion in bare areas caused by foot traffic, etc. on the upstream face. The abutment areas have a cover of grass and brush.	Seed bare areas to establish a grass cover and prevent progressive erosion.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Vertical and horizontal alignment of the crest is good, with no indication of settlement or other problems. The crest is crowned toward the center, such that elevations are higher there than at the abutments (see crest profile sketch).	None.
RIPRAP FAILURES	No riprap observed.	None.
FOUNDATION	The foundation appears stable.	None.
ANY NOTICEABLE SEEPAGE	There is a wet spot with standing water in the vicinity of the right abutment, near the foot path. There is a marshy area at the base of the left abutment, and what appears to be a line of seepage extending from the left abutment area about one third of the way across the downstream face of the dam.	Monitor the wet spots and of seepage during regular maintenance inspections. Should flow rates change without explanation or become turbid, contact a geotechnical consulting firm for further evaluation.

EMBANKMENT
UPPER APPLE MOUNTAIN

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
DRAINS	None were apparent.	None.
MATERIALS	Materials used to construct the dam are presumed to be from local borrow areas, and appeared to be residual silts and silty days of medium to high plasticity.	None.
VEGETATION	The dam has a fair grass cover. There is some underbrush on up and downstream faces: locust saplings, sumac, honeysuckle, and briers, with cattails at the waterline.	Keep embankment clear of underbrush, and remove brush piles that are presently on the crest of the dam. Efforts should focus on developing and maintaining a good grass cover on the embankment.

PRINCIPAL SPILLWAY
UPPER APPLE MOUNTAIN

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONTROL SECTIONS	There is an 18 inch corrugated metal pipe with a 24 inch CMP trashguard located just beyond the shoreline, which serves as an intake structure. The vicinity is crowded with cattails.	Keep intake structure clear of cattails and other obstructions.
APPROACH CHANNEL	NA	
DISCHARGE CHANNEL	The outlet is a 12 inch CMP, with a dense growth of cattails immediately below it. There is an animal burrow where the pipe enters the embankment. At the time of the inspection, the outlet was discharging a trickle of water.	Close animal burrow with compacted fill, and check embankment periodically for new burrows.
BRIDGE AND PIERS	NA	
EMERGENCY GATE	A pole standing vertically in the lake beyond the intake structure suggests that the lake may have been constructed with an emergency drain. It was not possible to determine if a gate drain was actually present.	Investigate this area during a period of low water or a diver to determine whether a low level drain is actually present.
GATES AND OPERATION EQUIPMENT	None observed.	None.

EMERGENCY SPILLWAY
UPPER APPLE MOUNTAIN

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONTROL SECTIONS	The emergency spillway is a shallow earthen side channel ditch of roughly trapezoidal cross section in natural ground at the left abutment.	None.
APPROACH CHANNEL	The approach to the emergency spillway channel is a gentle slope partially obstructed by brush and small trees.	Clear approach channel and spillway of all brush and trees.
DISCHARGE CHANNEL	The emergency spillway discharges down the left abutment contact, which is partially blocked by brush and small trees.	It is generally desirable to protect the embankment of a dam from emergency spillway flows by a berm or other means. This is less important where flows through spillway are likely to be infrequent and small.
BRIDGE AND PIERS	NA	
MISCELLANEOUS	NA	

INSTRUMENTATION
UPPER APPLE MOUNTAIN

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None.	None.
OBSERVATION WELLS	None.	None.
WEIRS	None.	None.
PIEZOMETERS	None.	None.

INSTRUMENTATION
UPPER APPLE MOUNTAIN

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
STAFFGAGES	None.	Install a staff gage, which is a staff, rod, or post with elevations indicated on it permanently mounted in a lake to show the depth the water. It should be of sufficient height to indicate the depth of flow through the emergency spillway.
OTHER	None.	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	The reservoir is surrounded by steep and wooded slopes; there is no indication that the slopes are unstable.	None
SEDIMENTATION	Not measured.	None.

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS), DEBRIS, ETC.)	The reservoir of the Lower Apple Mountain is immediately downstream.	None
SLOPES	NA	
APPROXIMATE NO. OF HOMES AND POPULATION	There are a couple of frame dwellings and a mobile home some distance below the Lower Apple Mountain Dam. The release of water from a failure of the Upper Apple Mountain Dam could have a serious impact on the Lower dam, and hence pose a threat to the downstream area below it.	Develop an emergency warning plan to safeguard the lives and property of those living below the dam.

Check List
Visual Inspection
Phase I

Name Dam: Lower Apple Mountain County: Warren State: Virginia Coordinates: Lat. 38° 55.9'
Long. 78° 16.4'

Date Inspection: 19 Mar 81 Weather: Partly cloudy & cold Temperature: 35° - 35° F

Pool Elevation at Time of Inspection: 95.4 TBM* Tailwater at Time of Inspection: 95.4 TBM*

Inspection Personnel:

B. Taran, COE
J. Robinson, COE
D. Pezza, COE
L. Jones, COE
E. Constantine, SWCB
H. Gildea, SWCB
D. Bushman, SWCB
L. Musselwhite, SWCB

Apple Mountain
Property Owners Association:

Mr. Ed. Jewel

H. Gildea Recorders

*TBM - Temporary Bench Mark: Concrete wall at right abutment of Lower Apple Mountain Lake, assumed to be at elevation 100.0 feet. (MSL)

EMBANKMENT
LOWER APPLE MOUNTAIN

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	No surface cracks were observed.	None.
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	No unusual movement or cracking was observed. The toe area is overgrown with brush and small trees.	Keep the toe area clear of underbrush to facilitate the observation of unusual seepage, piping, or other problems in the toe area.
SLOUCHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	There is a ditch caused by erosion at the right abutment contact on the downstream side, caused by hillside runoff. One animal burrows was noted on the downstream face.	Fill ditch with compacted earth, and seed to prevent progressive erosion in the area. Close animal burrows with compacted fill, and check embankments periodically for new burrows.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Vertical and horizontal alignment of the crest is good, with no indication of settlement or other problems. The crest is crowned toward the center, such that elevations are higher in that portion of the crest than at the abutments (see crest profile sketch).	None.
RIPRAP FAILURES	No riprap observed.	None.
FOUNDATION	The foundation appears stable.	None.

EMBANKMENT
LOWER APPLE MOUNTAIN

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	Evidence of seepage and some standing water is widespread in the area beyond the toe of the dam. There is a wet spot with flowing water in the lower portion of the left abutment contact, with a flow estimted to be 3 gpm.	The wet spot at the left abutment may be a natural spring. Monitor the wet spots and areas of seepage during regular maintenance inspections. Should flow rates change without explanation or become turbid, contact a geotechnical consulting firm for further evaluation.
DRAINS	None were observed.	None.
MATERIALS	Materials used to construct the dam are presumed to be from local borrow areas, and appeared to be residual silts and silty clays of medium to high plasticity.	None.
VECETATION	The dam has a fair grass cover. There are cattails on portions of the dam at the waterline, and a few bushes on the upstream face. The downstream face is covered with locust saplings.	Remove bushes and saplings from the faces of the dam. Maintenance efforts should focus on developing and maintaining a good grass cover on the embankment.

PRINCIPAL SPILLWAY
LOWER APPLE MOUNTAIN

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONTROL SECTIONS	There is an 18-inch corrugated metal pipe (CMP) with a 24-inch CMP trashguard located a short distance offshore serving as an intake structure.	None.
APPROACH CHANNEL	NA	
DISCHARGE CHANNEL	The outlet is a 12-inch CMP, which discharges into a very small plunge pool surrounded by saplings. At the time of the inspection, the outlet was discharging a trickle of water.	Remove underbrush from the plunge pool area and line with riprap to prevent erosion and scouring from outlet flows.
BRIDGE AND PIERS	NA	
EMERGENCY GATE	A pole standing vertically in the lake beyond the intake structure suggests that the lake may have been constructed with an emergency drain. It was not possible to determine if a gate drain was actually present.	Investigate this area during a period of low water or with a diver to determine whether a low level drain is actually present.
GATES AND OPERATION EQUIPMENT	None observed.	None.

EMERGENCY SPILLWAY
LOWER APPLE MOUNTAIN

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONTROL SECTIONS	The emergency spillway is U-shaped earthen side channel at the left abutment.	None.
APPROACH CHANNEL	The approach channel has a few bushes and a small quantity of small logs and sticks.	Keep clear of brush and other debris.
DISCHARGE CHANNEL	The emergency spillway discharges into the area of the left abutment contact, which is partially covered by brush and trees.	It is generally desirable to protect the embankment of a dam from emergency spillway flows by a berm or other means. This is less important where flows through spillway are likely to be infrequent and small.
BRIDGE AND PIERS	NA	
MISCELLANEOUS	NA	

INSTRUMENTATION
LOWER APPLE MOUNTAIN

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None.	None.
OBSERVATION WELLS	None.	None.
WEIRS	None.	None.
PIEZOMETERS	None.	None.

INSTRUMENTATION
LOWER APPLE MOUNTAIN

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
STAFFGAGES	None.	Install a staffgage, which is a staff, rod, or post with elevations indicated on it permanently mounted in a lake to show the depth the water. It should be of sufficient height to indicate the depth of flow through the emergency spillway.
OTHER	None.	

RESERVOIR
Lower Apple Mountain

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	The terrain is steep and wooded, with pines predominating on the right impoundment and hardwoods on the lefthand side. There are a few fallen trees along the left shoreline.	None
SEDIMENTATION	Not measured.	None.

DOWNSTREAM CHANNEL
Lower Apple Mountain

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS), DEBRIS, ETC.)	The downstream channel is a natural streambed through woods.	None
SLOPES	The slopes are typical of natural watercourses in the area, which is characterized by hilly to mountainous terrain.	None
APPROXIMATE NO. OF HOMES AND POPULATION	There are a couple of frame dwellings and a mobile home some distance below the dam.	Develop an emergency warning plan to safeguard the lives and property of those living below the dam.

APPENDIX IV

REFERENCES

APPENDIX IV

REFERENCES

1. Recommended Guidelines for Safety Inspection of Dams, Office of the Chief of Engineers, Department of the Army, Washington, D. C.

2. HEC-1 Flood Hydrograph Package, (Hydrologic Engineering Center, U. S. Army Corps of Engineers, January 1973.)

3. NWS-Dambreak Computer Model, (Office of Hydrology, National Weather Service (NWS), Silver Spring, Maryland, September 1980).

4. "Probable Maximum Precipitation Estimates, United States East of the 105th Meridian," Hydrometeorological Report No. 51, (National Weather Bureau, June 1978).

5. "Rainfall Frequency Atlas of the Unites States", Technical Paper No. 40, (U.S. Weather Bureau, May 1961).

6. Report of Investigations 44: Geology of the Linden and Flint Hill Quadrangles, Virginia, Michael T. Lukert and Ernest B. Nuckels III, (Virginia Division of Mineral Resources, 1976).

7. "Design of Small Dams", Technical Publication of United States Department of the Interior, Bureau of Reclamation, Second Edition, Revised Reprint, 1977.